Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

CANMET

Canada Centre for Mineral and Energy Technology | Centre canadien de la technologie des minéraux et de l'énergie

FIELD VERIFICATION OF TBM SHOP FLOOR VENTILATION TRIALS

A.W. Stokes
Cape Breton Coal Research Laboratory

March 1985

This document is an unedited
(CANMET)

(CANMET)

MICROMEDIA

JUL 03 1985

ENERGY RESEARCH PROGRAM
COAL RESEARCH LABORATORIES
DIVISION REPORT ERP/CRL 85-17(TR)

FIELD VERIFICATION OF TBM SHOP FLOOR VENTILATION TRIALS

by

A.W. Stokes*

ABSTRACT

An extensive series of tests were performed on the shop floor of Lovat Tunnelling Equipment to determine the effectiveness of a 7.6 m diameter full face tunnel boring machine's head ventilation system. These tests showed that the system would be adequate to remove methane and dust produced at the cutting face and maintain a safe mining environment.

After more than 3 km of tunnel had been driven with the tunnel boring machine, a field verification test was performed underground during one of its normal operating cycles. This report outlines the results of this field verification survey.

---

*Research Scientist, Cape Breton Coal Research Laboratory, CRL, CANMET, Energy, Mines and Resources Canada, Sydney

VÉRIFICATION SUR LE TERRAIN D'ESSAIS EN ATELIER PORTANT SUR LE SYSTÈME D'AÉRATION DU TUNNELIER (TBM)

par

A.W. Stokes*

RÉSUMÉ

Une série exhaustive d'essais a été effectuée à l'atelier de la Lovat Tunnelling Equipment pour déterminer l'efficacité du système d'aération de la tête d'un tunnelier à section entière d'un diamètre de 7,6 m. Les essais ont démontré que le système d'aération serait en mesure d'éliminer les émanations de méthane et la poussière qui se dégagent au front de taille et pourrait maintenir un environnement atmosphérique sécuritaire dans les mines souterraines.

Après le forage de plus de 3 km de tunnel à l'aide du tunnelier, on a effectué une vérification sur les lieux dans la mine souterraine alors que la machine était en cycle d'opération normal. Le présent rapport porte sur les résultats obtenus lors du contrôle sur le terrain.

---

*Chercheur scientifique, Laboratoire de recherche sur le charbon du Cap-Breton, LRC, CANMET, Énergie, Mines et Ressources Canada, Sydney

CONTENTS

	Page
ABSTRACT	i
RESUME	ii
INTRODUCTION	1
FIELD TRIAL METHODOLOGY	1
RESULTS	2
CONCLUSIONS	3
REFERENCES	4

TABLES

No.		
1.	Results of the underground verification test	5

FIGURES

No.		
1.	Field verification test results	6
2.	Concentration/time curve for comparable shop floor test, point 7	7

INTRODUCTION

During May of 1983 an extensive series of tests were conducted on the shop floor of Lovat Tunnelling Equipment Ltd. to determine the effectiveness of the head ventilation system of their new 7.6 m diameter full face tunnel boring machine (TBM). In brief, this was achieved by constructing a shroud around the front end of the TBM (representing the tunnel face and walls), connecting up appropriate fans and then injecting pulses of propane tracer gas through 22 points across the cross section of the cutting face. The concentrations of propane reporting to the exhaust airstream drawn from the cutting head area were measured and these allowed the ventilation efficiency of the system to be determined. A detailed description of the physical construction of the TBM is given by Hunter (1), whilst a more detailed description of the shop floor trials and the results obtained has been presented by the authors (2).

The shop floor investigations produced several hundred exhaust gas tracer concentration/time curves obtained for the injection points for a variety of machine operating conditions. The results indicated that the machine could be safely used to mine through gassy strata with little risk of explosions as experienced elsewhere (3).

After the TBM had been in operation for over one year and had driven in excess of 3.3 km of tunnel, an underground verification was done to assess the effect of the variables which could not be simulated in the shop floor trials (e.g. falling rock cuttings and water sprays). It also provided an opportunity to determine the extent of the degradation in the system as a consequence of over one year's mining.

FIELD TRIAL METHODOLOGY

To assess the effective difference between the TBM ventilation system as measured on the shop floor to its performance underground a comparative test was needed. This was achieved by repeating a pulse injection of tracer gas at one of the face locations tested on the shop floor.

A known volume of tracer gas (10 ml of SF_6) was injected into a incandescent light bulb which was thrown through the conveyor hole to impact

on the rock face while the TBM was in normal operation. Twenty-two short duration grab samples were collected from the exhaust duct in gas sample bags using a procedure described by Kennedy (4). Twelve 5 second duration samples were collected back-to-back for the first 60 seconds after the injection followed by ten 7 second duration samples collected at the start of every 15 second period thereafter. Hence samples of exhaust air were collected for three minutes after the release of tracer gas.

Machine operating characteristics were measured as accurately as conditions allowed. The exhaust and forced airflows were found by pitot tube traverses in the appropriate ducts and the cutter head rotational speed was estimated by visual observation.

Air samples were collected from the tunnel before the injection of tracer gas to determine the background level of SF_6, if any.

RESULTS

A gas chromatograph utilising an electron capture detector was used in the laboratory to analyse the air samples. Table 1 shows the concentrations of SF_6 measured in the gas bag samples. Figure 1 is a histogram of the results showing the concentration of SF_6 in the exhaust airstream versus the elapsed time since the tracer gas was released. The dashed line is the concentration/time curve inferred from the histogram.

The airflows measured by the pitot tube traverses were 2.6 m^3/s in the forcing duct and 6.4 m^3/s in the exhaust. The exhaust flow agrees closely with the flow calculated, by dividing the area under the curve in Figure 1 by the volume of tracer gas injected, from the equation:

$$Q = \frac{Vg}{\int C.dt.} \quad (m^3/s) \qquad \text{Eq 1}$$

where Q = exhaust flowrate (m^3/s)
Vg = volume of tracer gas injected (m^3)
C = exhaust tracer gas concentration
t = lapsed time since injection (s)

This volume works out to be 6.1 m^3/s

No test was ever conducted on the shop floor for precisely these operating conditions. However, Figure 2 shows a concentraton/time curve for injection point number 7 (approximate location of field tracer gas release) measured with somewhat similar operating conditions. The operating conditions were: forced airflow = 4.1 m^3/s, exhaust airflow = 8.7 m^3/s and cutterhead rotation = 4 rpm.

Despite the slightly different operating conditions, the agreement between the curves is very good. Both are almost identical in shape. The time between the first two peaks in both, correspond closely with the time taken for a complete revolution of the cutter head. That is 15 seconds for the shop floor curve and 20 seconds for the curve obtained in the field.

The time taken to remove 50 percent of the tracer gas are related closely to the exhaust flow rate drawn from the cutter head. The time for the curve in Figure 1 is slightly longer than in Figure 2 due to the lower exhaust flow rate.

CONCLUSIONS

The method employed for evaluating the TBM's ventilation system underground worked well allowing the results to be compared with those obtained during the shop floor trials.

The additional factors that influence the ventilation underground which could not be simulated during the shop floor trials, namely falling rock cuttings and dust suppression sprays, have little overall effect on the efficiency of the cutter head ventilation system. After more than one year of operation the system performs near to its design value with little fall in ventilation efficiency.

The adequacy of the cutter head ventilation system was demonstrated by the fact that the methane concentration measured in the exhaust ventilation stream from the cutter head never exceeded 0.4% (5) CH_4 during the drivage of tunnel number 2.

REFERENCES

1. Hunter, J.A. and Lovat, R. "Design, development and verification of a Lovat 7.6 metre full face tunnel boring machine"; CIM Bulletin; pp 47-55; May 1984.
2. Stokes, A.W. and Stewart, D.B. "Ventilation trials of a full face tunnel boring machine"; Proceedings of the 3rd International Mine Ventilation Congress; p. 81; 1984.
3. Stokes, A.W. and Geller, L.B. "Ventilation and safety related problems when driving headings in coal mines with full face tunnel boring machines"; CANMET Divisional Report ERP/CRL 83-22(TR); 1984.
4. Kennedy, D. "Tracer gas addition and sampling procedures for response situations underground"; CANMET Divisional Report ERP/CRL 85-17(TR); March 1985 (in preparation).
5. Private Communication with J.C. Marsh, Donkin-Morien Mine Manager.

Table 1 - Results of the underground verification test

Sample Number	Time Duration	SF_6 Concentration
Background	-	Less than 0.1 ppb
1	0 - 5 sec	0.63 ppb
2	5 - 10 sec	74.39 ppb
3	10 - 15 sec	116.83 ppb
4	15 - 20 sec	10.29 ppb
5	20 - 25 sec	10.65 ppb
6	25 - 30 sec	28.06 ppb
7	30 - 35 sec	26.44 ppb
8	35 - 40 sec	10.07 ppb
9	40 - 45 sec	8.63 ppb
10	45 - 50 sec	8.27 ppb
11	50 - 55 sec	6.4 ppb
12	55 - 60 sec	4.49 ppb
13	60 - 67 sec	3.31 ppb
14	75 - 82 sec	1.65 ppb
15	90 - 97 sec	1.08 ppb
16	105 - 112 sec	0.36 ppb
17	120 - 129 sec	0.19 ppb
18	135 - 142 sec	0.13 ppb
19	150 - 157 sec	0.55 ppb
20	165 - 172 sec	0.10 ppb
21	180 - 187 sec	0.04 ppb
22	195 - 202 sec	0.02 ppb

(Background sample taken 10 minutes before SF_6 injection)

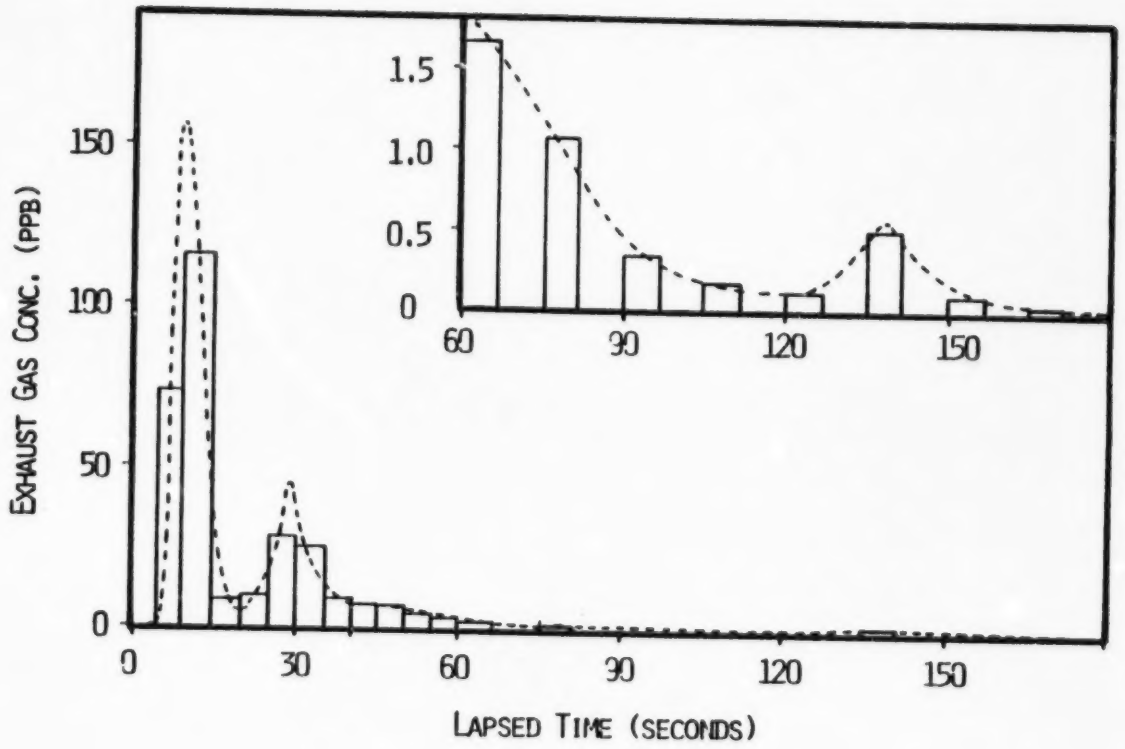

Figure 1 - Field verification test results

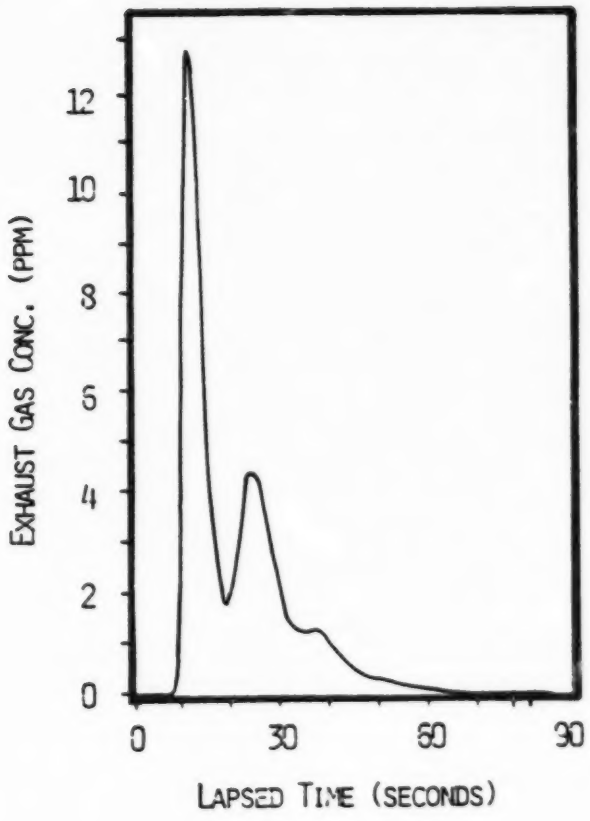

Figure 2 - Concentration/time curve for comparable shop floor test, point 7